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Potential Production in Thinned Douglas-fir Plantations

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INTRODUCTION

More Douglas-fir stands are being placed under some degree of intensive management each year in the Pacific Northwest. This requires considerable investment that might be allocated to other uses. Justification of such investments requires information about potential yields which, unfortunately, is relatively scant because few Northwest stands have been under management as many as 40 years--most early studies imposed thinnings that many American foresters today would consider too infrequent and, perhaps, too late.

A relatively unexploited source of information about potential yields of frequently thinned Douglas-fir plantations is the increasing number of Douglas-fir production tables from foreign countries. These tables are theoretical thinning guides which list periodic statistics on stands after thinning, thinning yields, and their sum, which is total production, for as many as 50 to 80 years. Indicated yields are based on examination of sample plots in 50 to 100 or more thinned plantations which serve as guides to total production that can be expected on different sites. These field plots sample many different thinning regimes and are likely to have been located in the more successful parts of the examined plantations. Degree and frequency of thinning in the production tables are prescribed by the authors, sometimes on the basis of experience with thinning trials of other conifers. As a result, there is more variation between tables in number of stems and average diameters specified for any age and site than in total volume production. These tables indicate higher potential gains in production and tree size from intensive thinning regimes than some previous local calculations and suggest that heavy thinning schedules have early culmination of volume production, and relatively short rotations.

Several production tables have been mentioned in North American literature (Barnes 1955, 1956; Barrett 1962; Briegleb 1952; Heiberg and Haddock 1955; Hoyer 1967; Staebler 1960; Warrack 1959).[1/] These tables were all from northern Europe, and some questions have been raised about effect of climatic differences on potential production. Although equally low average temperatures can be found at higher elevations in the Pacific Northwest, lack of summer dry

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1/ Names and dates in parentheses refer to Literature Cited, p. 16.

spells and resulting longer moist seasons in northern Europe could stimulate diameter growth more than height growth. This different balance of diameter and height growth would increase volume growth more than it would increase site index. It is not known how lower annual precipitation, shorter growing seasons, longer summer hours of daylight, and differences in soils affect the relation between height and diameter growth.

Therefore, production tables now available for mountainous areas of northern Italy and southern France are of particular interest. There, the latitudes and climates (mean annual temperature 48° to 50° F., rainfall 30 to 80 inches, and two dry summer months) correspond quite closely to those of Washington and Oregon.

Estimates of potential yields on a high site are available from New Zealand (Duff 1956; Spurr 1963). As will be seen later, it is difficult to distinguish possible effects on yield of differences in climate and soil from differences in thinning schedules and other causes. Data from all recent sources are presented and discussed.

BASES FOR COMPARISON

To make information in these production tables useful, it is necessary to identify them with areas of comparable productivity in the Pacific Northwest. The measure of productivity most often used in the Northwest is site index based on height of dominant and codominant trees at 100 years, as shown in U.S. Department of Agriculture Technical Bulletin 201 (McArdle et al. 1961). The European tables rate productivity on the basis of volume produced, but usually give either a stand mean height or an average height of some taller part of the stand, the latter corresponding closely, but not exactly, to height of dominants in natural stands. Johnston and Bradley (1963) point out that although the new British management tables classify stands on the basis of volume production, height-age relations are still used to determine yield class. They further state that the volume production in particular stands so classified may deviate from tabulated volume production by as much as 50 percent. Therefore, they introduce a secondary classification for local yields. This consists of three classes representing differences in mean annual production of about 22.6 cubic feet inside bark per acre centered around the production class indicated by the height-age relation.

Apparently, all European Douglas-fir production tables are for the coastal variety. Winter damage to coastal Douglas-fir planted in Prussia led to trials of the interior variety, but these were heavily damaged by needle disease (*Rhabdocline* sp.) (Kanzow 1937). Today, the only form other than coastal considered worth planting in most of Europe is an intermediate form from

British Columbia (Göhre 1958). Plantings of this form are generally too young to have been used as indicators of volume production.

Most but not all European volume figures include bark but exclude a low stump and the tip smaller than 3 inches in diameter outside bark. As well as could be determined, all ages were from date of germination, except in British and New Zealand tables where ages were from date of planting.

Since some of the tables ended at 50 years and total cubic-foot production culminated near that age, it was decided to compare production at that age. This reduces the number of production tables available for heavily thinned stands from three to two since a table from The Netherlands included only 30 years (Van Laar 1954).

Details of adjustments made to identify sites and to place all volume estimates on a common base are in Appendix I.

RESULTS OF COMPARISONS

Total production of thinned foreign plantations at 50 years (expressed as cubic feet under bark including tip and stump) ranged from about 75 to 400 cubic feet per acre per year (fig. 1). However, most estimates fell between 125 and 300 cubic feet. The average site index of stands producing 125 cubic feet appears to be about 95--the dividing line between sites IV and V.[2/] Production of 300 cubic feet per year for 50 years is indicated on an average site index of 155--between sites II and III. Site index 125 averages about 200 cubic feet total production. These average estimates of total production are higher than net yields tabulated by McArdle et al. (1961) or gross yields estimated by Staebler (1955b) and Curtis (1967) for natural stands in the Northwest (table 1). Differences between Staebler's gross yields, based on McArdle's temporary plots, and Curtis' gross yields, based on plot growth, are due in part to use of different data and in part to differences in analysis procedures. The closer approach of Curtis' estimates to the foreign production estimates indicates the possible error in estimating managed yields from normal yield tables for dense unmanaged stands derived from temporary plots.

2/ All site estimates in this paper are based on USDA Tech. Bull. 201, The Yield of Douglas-fir in the Pacific Northwest (McArdle et al. 1961).

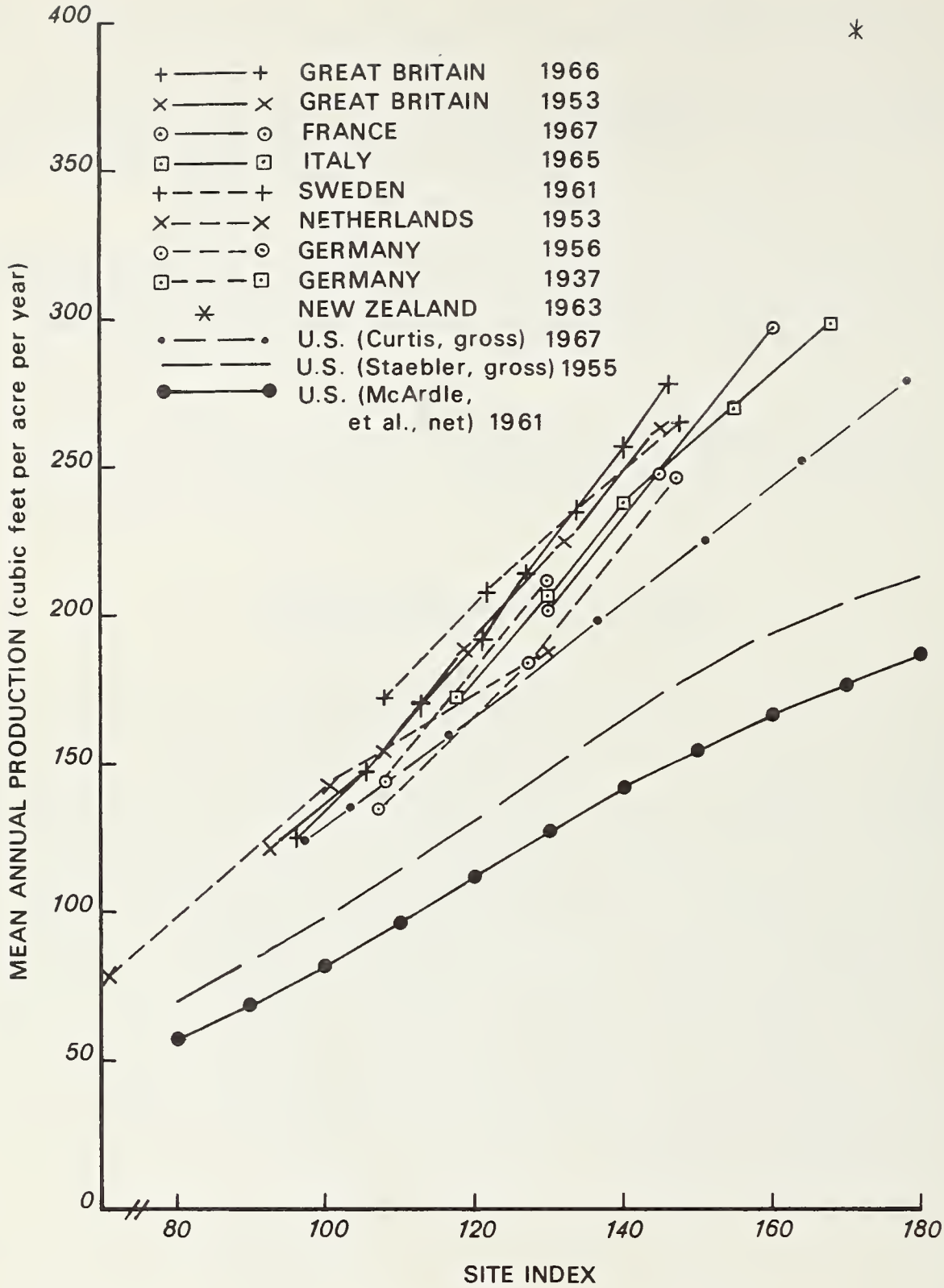

Figure 1.—Douglas-fir total production at about 50 years.

Table 1.--*Comparison of estimated yield of 50-year-old Douglas-fir stands*

Source of estimates	Site index		
	95	125	155
	------Cubic feet per acre per year------		
Foreign countries (total production of thinned plantations)	125	200	300
United States:			
McArdle et al. (1961) (net yield)	75	120	160
Staebler (1955b) (gross yield)	90	140	190
Curtis (1966) (gross yield)	120	175	235

These production figures are for fully stocked acres--for gross acreages, a reduction of 15 percent for roads, failed spots, and other openings, suggested by Bradley et al. (1966), seems reasonable for easy terrain. In rugged mountains, roads, rock outcrops, and other openings may take an even greater toll of productive area. These 50-year production rates are close to the maximum possible, since in these tables mean annual total production culminates at about 50 years on site 140 and 60 years on site 100 (fig. 2). (These "total" figures include both volumes to tip and to 3-inch top outside bark, since latter were adjusted by flat percentage which increases amount of volume production but has no effect on age of culmination of volume production.)

Only the British tables give information on volume production to other top limits. In these tables, culmination of mean annual "saw-log" production (volume to 7-inch top o.b.) is later than that of total production by 12 to 15 years. Culmination is based on seedling age to make it comparable with other data. Plantation age is 3 years lower. Volume production measured in cubic feet to a 7-inch top is about 80 percent of total production--in other words, about 20 percent of production is in trees or tops under 7 inches in diameter outside bark. Culmination of mean annual production at 65 to 80 years for volume to 7-inch top is earlier than indicated by McArdle (1961) for trees over 7 inches d.b.h. to a 5-inch top or than calculated by Staebler (1955a, 1955b) by addition of apparent mortality to normal net yield. Normal yield tables for natural stands are not well suited for calculation of rotations, even of natural stands, since they do not trace the growth of any stand.

It is likely that heavily thinned stands have shorter rotations than lightly thinned stands since repeated thinnings remove increasingly larger trees from the stand. The larger the holes the longer it takes surrounding trees to grow roots into the openings and otherwise adjust to their new environment. With heavy thinnings, a large percent of volume is removed early, and this reduction in stand efficiency may be felt at a younger age than with light thinnings.

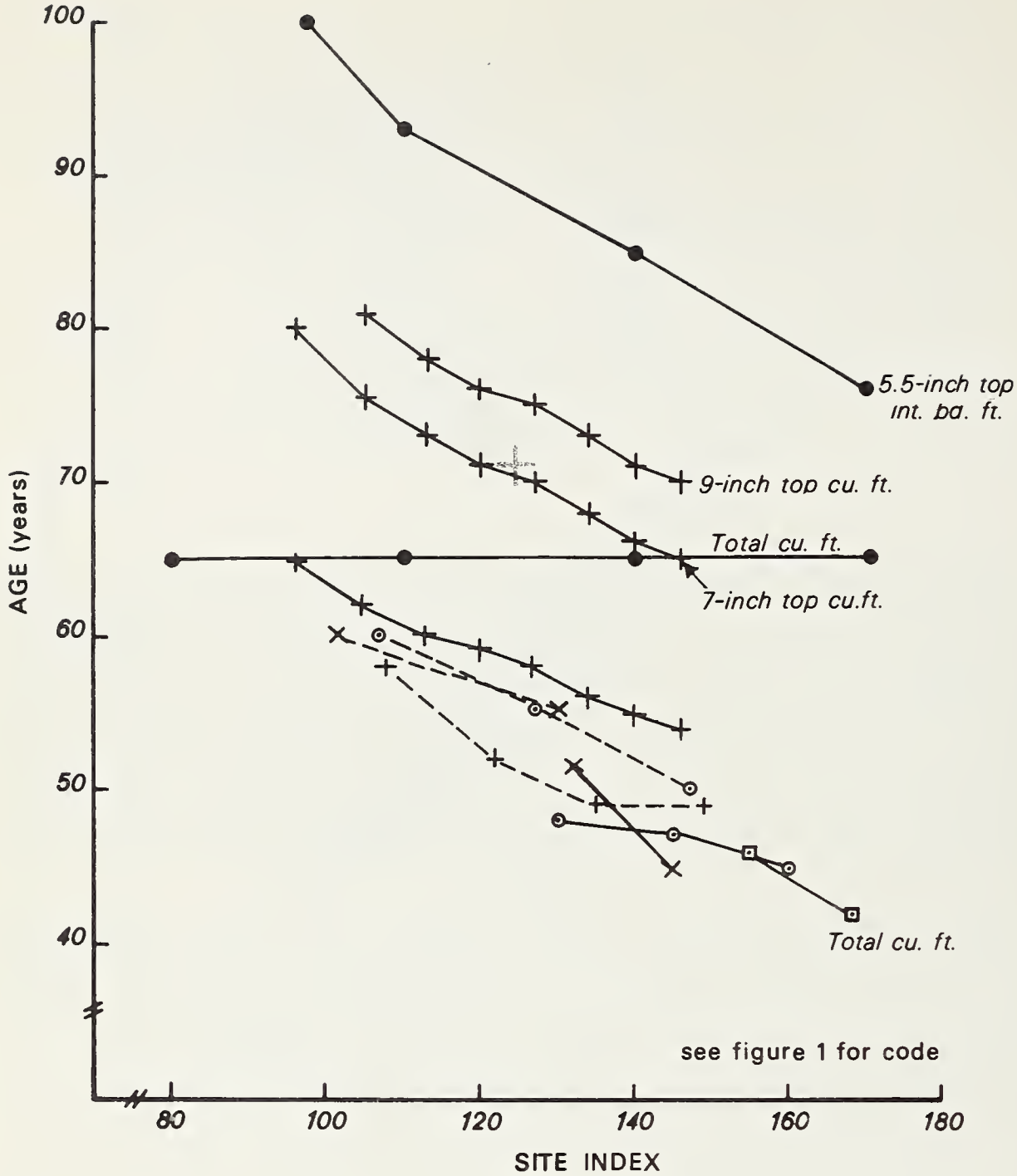

Figure 2.—Age at culmination of mean production. Numbers indicate top diameter outside bark.

Since the British tables suggest high-intensity thinnings, they offer no direct evidence about the effect of low-intensity thinning schedules on rotation length. However, as Johnston and Bradley (1963) point out, the highest intensity schedule that does not reduce total production is much closer to the schedule dictated by economic analysis than any lower intensity regime. At time of planting, values of early and heavy thinnings discounted at compound interest may exceed the value of the final harvest, despite the lower value of smaller trees.

A measure of thinning intensity is useful in consideration of the yields indicated by foreign tables. Thinning intensity is determined both by number and size of trees removed in each thinning and by frequency of thinning. Johnston et al. (1967) define thinning intensity as average annual volume removed between the time of first thinning and end of last thinning. They call the volume removed in a particular thinning the thinning weight and the interval between thinnings the thinning cycle. Since thinning intensity is cumulative, any measure of intensity other than volume removed must include the effects of early thinnings on stand growth. Such a measure is provided by Reineke's (1933) stand density index, which rates density on the basis of number per acre and quadratic mean diameter. Table 25 of Bulletin 201 provides an easy basis for relative density ratings that are equivalent to Reineke's ratings.

For a comparison of thinning intensities, relative stand densities in the production tables were based on average diameters and numbers of stems before and after thinning. The numbers of stems were expressed as a ratio to the numbers for corresponding diameters in table 25 of Bulletin 201. The average ratio midway between thinnings was plotted to indicate the changes over time in relative density for each thinning schedule (fig. 3). This graph suggests quite different thinning regimes. The ones starting before 20 years begin with moderate relative densities--those starting after 20 years begin with high relative densities. The earlier British tables (Hummel and Christie 1953) and The Netherlands tables (Grandjean and Van Soest 1953) suggest moderate relative stand densities and hence moderate thinning intensities throughout. The recent British tables (Bradley et al. 1966) and the Swedish tables (Karlberg 1961 pp. 60-64)[3/] start with moderate densities and then reduce stands to low densities--indications of high-intensity thinnings. Curves for French (Decourt 1967) and German (Schober 1957) schedules suggest initial light thinnings becoming heavier at older ages. The Italian thinning tables (Cantiani 1965) start with moderate-to-high stand densities and become even denser. This suggests progressively lower thinning intensity.

[3/] Many of the data used by Karlberg were from the Danish plots that have been cited previously in American literature.

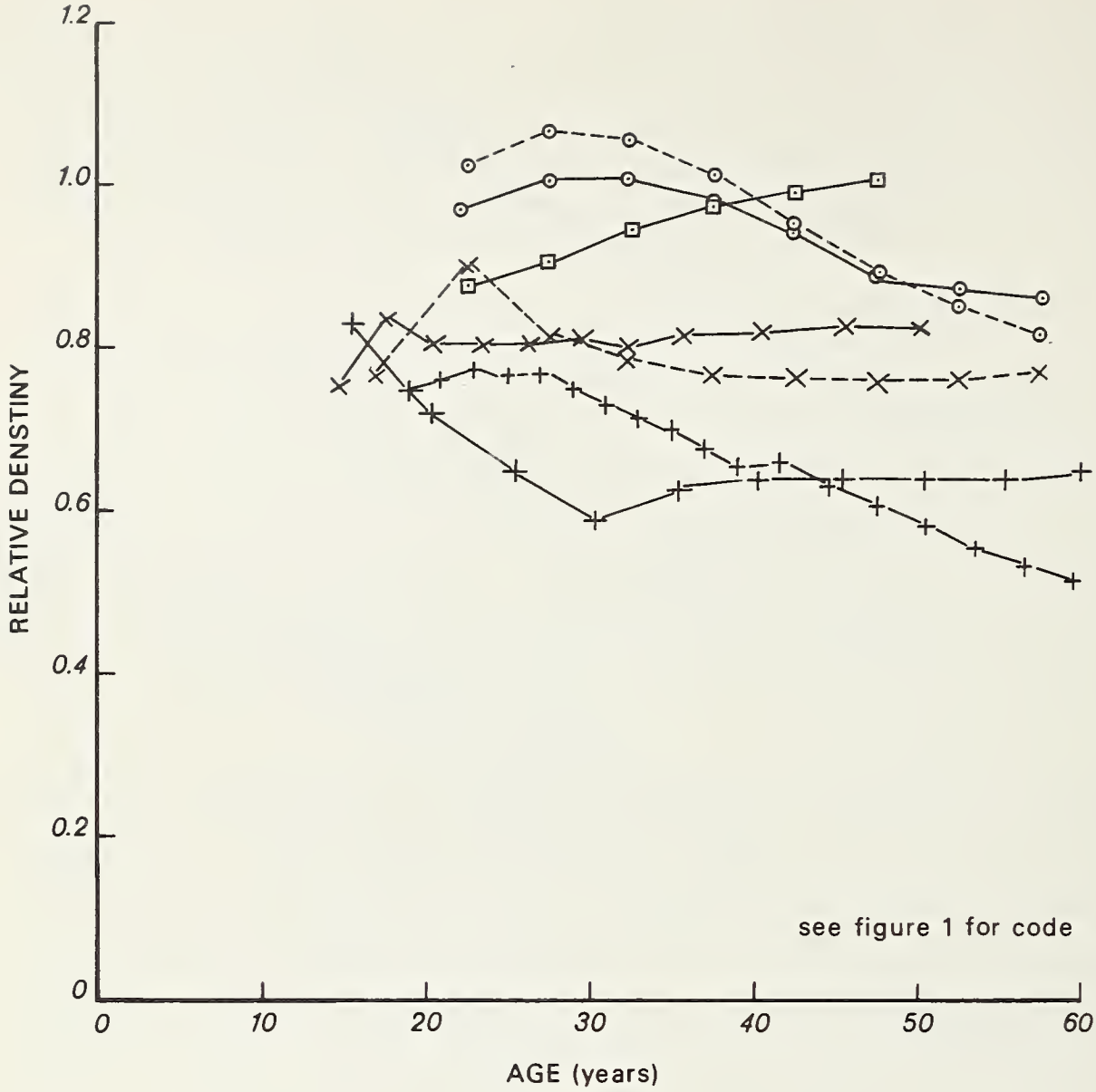

Figure 3.—Douglas-fir average relative density (site index range, 130-147).

When stand basal areas are substituted for stand density indexes in these comparisons, practically all stands are above normal at 25 years (fig. 4). This suggests Douglas-fir plantations generally can accrue basal area and volume faster at early ages than indicated by Bulletin 201. This is also true of some natural stands in the Pacific Northwest (Briegleb 1942). Some of the apparent differences in basal area can be attributed to differences in site index which had practically no effect on relative density comparisons.

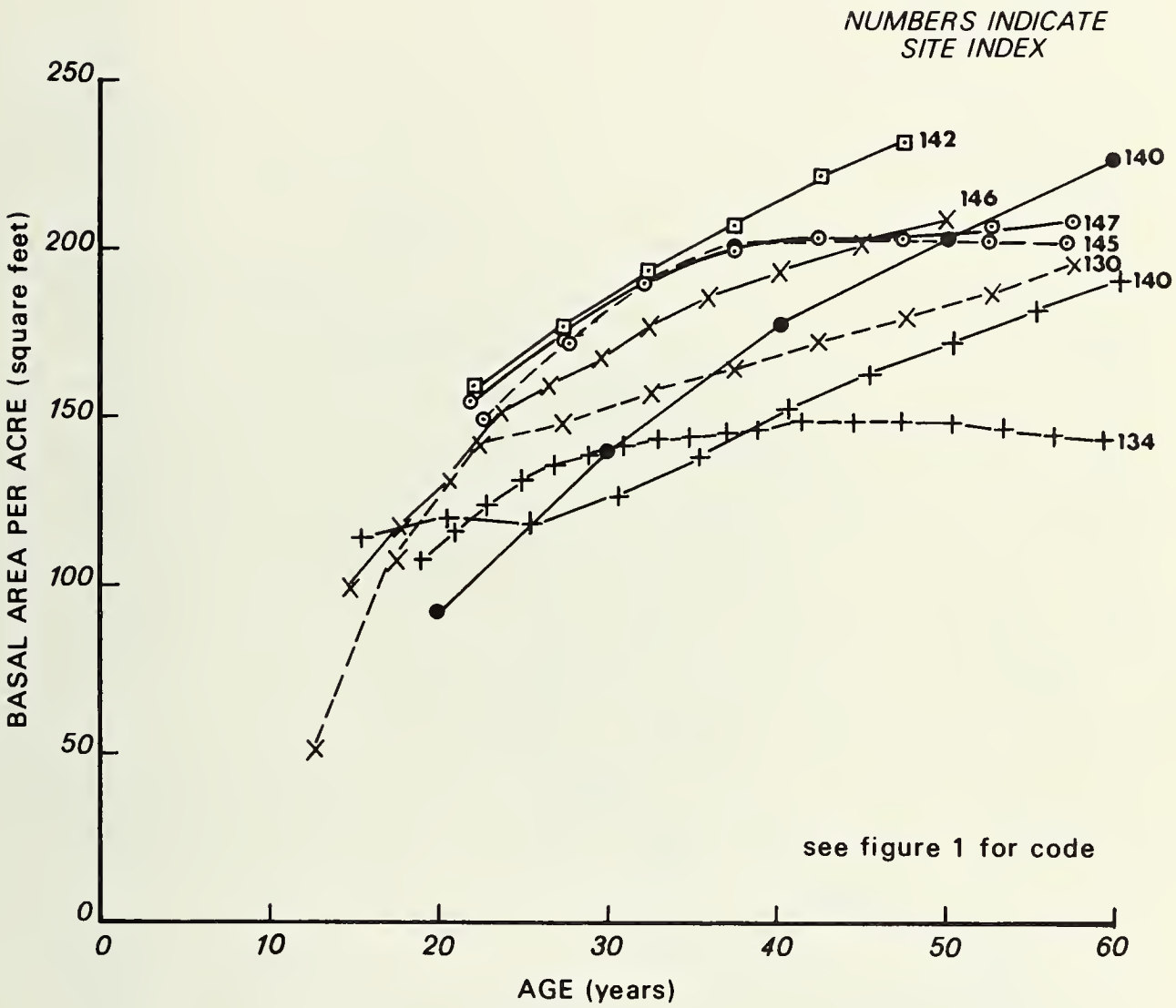

Figure 4.—Average basal area midway between thinnings (site index range, 130-147).

Basal area of residual stand at 50 years increases as site index increases (fig. 5). This increase is about 1 square foot per foot of site index. Relative amounts of basal area reflect the current weight of thinning at 50 years and because of the differences among thinning regimes cannot be related closely to total production. They are, however, closely related to volume of existing stand.

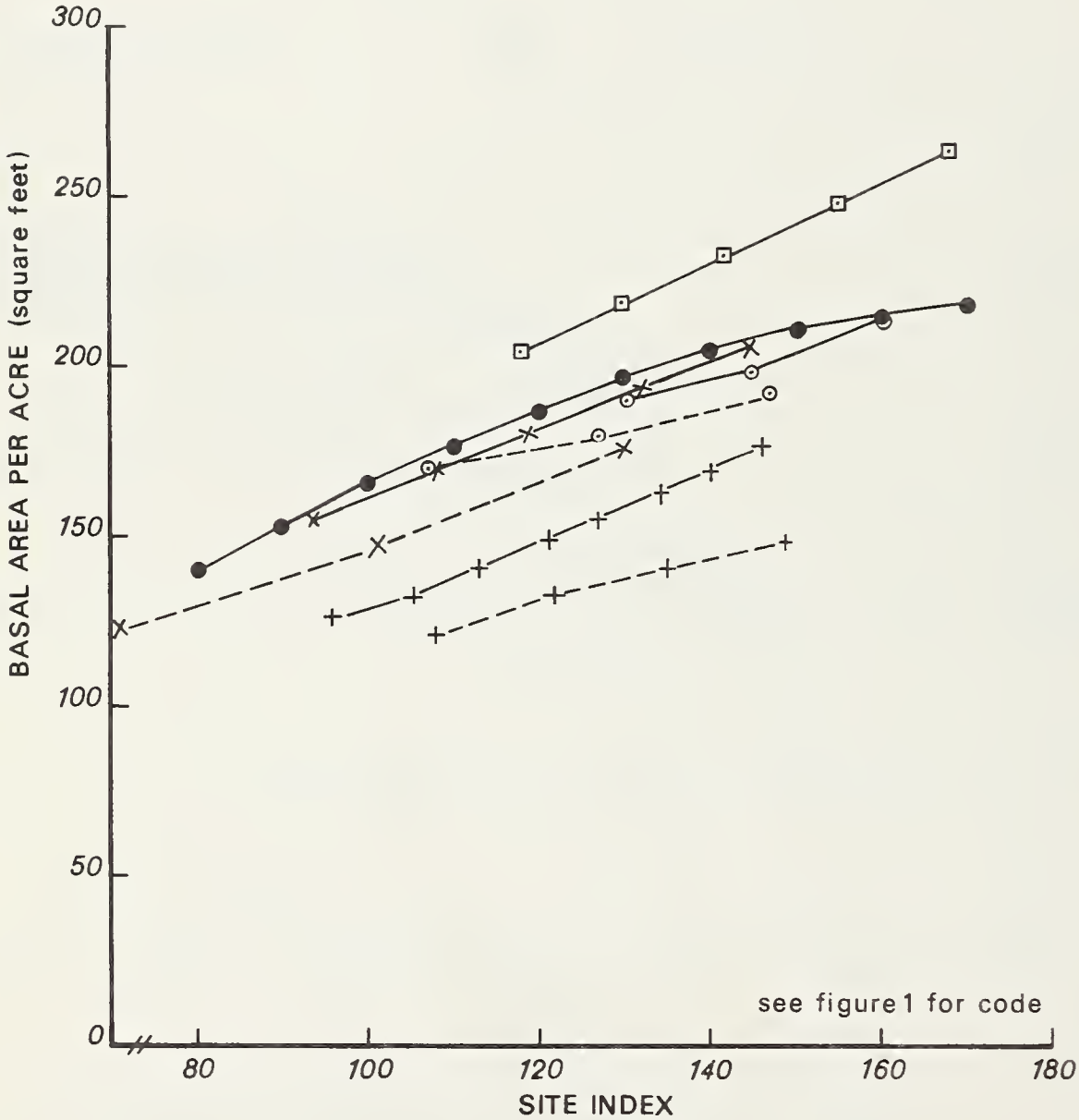

Figure 5.—Basal area at age 50 — stand after thinning.

Another means of judging thinning intensity is by comparison of numbers of stems per acre in the middle of the thinning cycles (fig. 6). These figures alone could have little meaning since they do not specify size of tree. However, if it is assumed that on equal sites diameter growth is inverse to number of

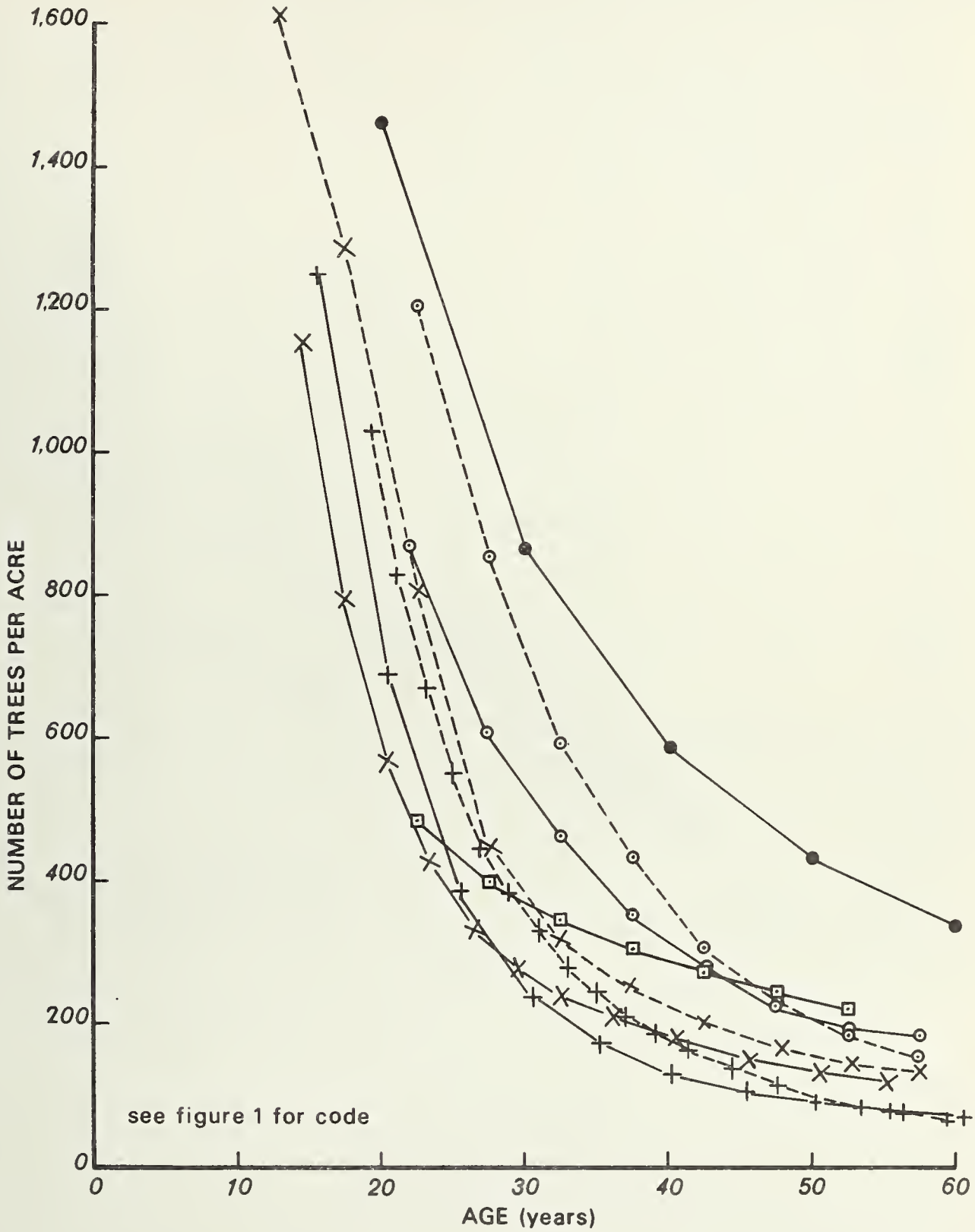

Figure 6.—Number of trees per acre midway between thinnings (site index range, 130-147).

stems, the sequences with fewest stems can be considered high-intensity thinning schedules. Examination of mean diameters after thinning (fig. 7) bears this out. Stands carried at low numbers of stems have larger diameters than those carried at relatively high numbers. These diameters indicate average size of tree available for harvest at each age. Many small trees must be removed by thinning before final harvest of the larger trees.

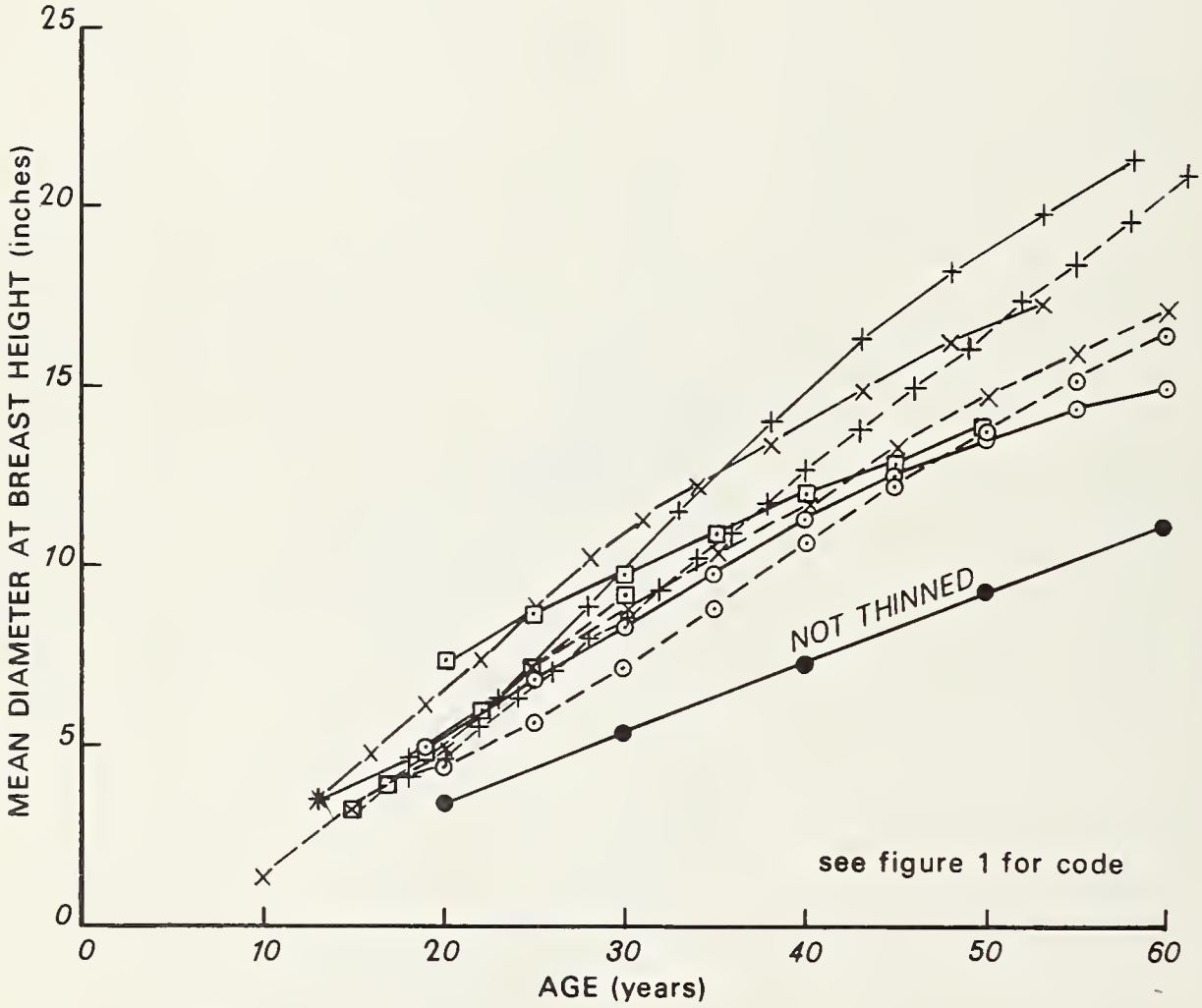

Figure 7.—Mean d.b.h. of residual stand immediately after thinning (site index range, 130-147).

Variations in thinning intensity appear to have less effect on total volume production than on average tree diameter (table 2).

Table 2.--*Stand statistics for age 50±, site 145±*

Country	Date published	Site index	Years from seed	Main crop				Production	
				Trees per acre	Mean d.b.h.	Basal area per acre	Volume per acre	Total	Mean annual
					In.	Sq.ft.	Cu.ft.	-----Cu.ft.-----	
Great Britain	1966	146	53	72	21.3	168	7,037	14,731	278
Great Britain	1953	145	53	125	17.2	205	8,238	13,915	263
France	1967	145	50	198	15.0	198	7,639	12,412	248
Italy	1965	142	50	225	13.8	225	8,875	11,912	238
Sweden	1961	149	49	86	17.8	149	5,719	13,043	266
Germany	1956	147	50	184	13.8	191	7,599	12,359	247

DISCUSSION

It was suggested that production tables from France and Italy might provide better estimates than those from more northern countries. Examination of the tables has suggested that thinning regimes prescribed for these two countries were much lighter than for most other countries, resulting in relatively low diameters at 50 years and relatively high basal areas and volumes in the residual stands. However, it is difficult to judge whether their somewhat low position in total volume production (fig. 1) is a result of climatic difference, thinning regime, or site classification. All indicated total production figures are encompassed in a band about 50 cubic feet wide (fig. 1). This is well within the limits of local yield variation reported by Johnston and Bradley (1963). If projected, this band would include the high yields reported in New Zealand.

Differences in average site index among production tables can be ascribed to both climate and soil. This average is 171 for New Zealand, 145 for France, 142 for Italy, and ranges from 128 to 101 for the northern countries. Differences between countries in climate and soil should cause similar differences in site index and volume production unless the climatic and edaphic differences affect the balance between diameter and height growth. Since figure 1 includes a wide

range of climates and soils, it is quite possible that Pacific Northwest yields would fall in the same 50-cubic-foot-wide band.

Highest volume production (in Sweden and Great Britain) is reported for thinning schedules with thinning starting before 20 years on site III and with high or moderate intensity thinnings. Generally, first thinnings are later on poorer sites. Thus, it seems reasonable to assume higher yields if thinnings start when top heights are 30 to 40 feet than if thinnings are postponed until top heights are 50 to 60 feet. These tables do not indicate the effect on yield of further postponement of thinnings.

All foreign production tables indicate thinnings at 2- to 5-year intervals. Johnston and Bradley (1963) suggest that there is little measurable difference in total yields if cycle is changed from 3 to 6 years on good sites or from 4 to 8 years on poor sites. It can be argued that repeated short delays in full site utilization in short thinning cycles have less effect on total volume production than fewer and longer delays with longer thinning cycles. This is mainly because the stand fluctuates less in relative density and area occupancy. Whether there is a measurable difference in production for 10-year thinning cycles compared with those in foreign tables is a moot question.

These production tables offer no information on increases in potential yields from intensive management practices other than thinning and weeding. In areas where brush and weeds can impede growth, weeding appears to be a standard practice in most foreign plantations. On soils where fertilizer improves tree growth, it is reasonable to assume that fertilizer application temporarily increases site productivity. Pruning has more effect on quality than on growth as long as it is limited to the lower live crown. Superior genetic stock in competition with inferior stock has dramatically better growth, and probably will have greater production when grown in solid blocks.

Forest managers in the Northwest cannot defer improved management of young Douglas-fir stands until pilot tests of planting and thinning can be completed. Other checks on these foreign thinning guides are possible. One key indicator of their applicability in the Pacific Northwest is current total annual increment. In the foreign tables on site 140, it culminates at 28 to 34 years, and mean total annual increment culminates at 49 to 52 years. In other species fully stocked when young, age at culmination of current annual increment (c. a. i.) is also about 60 percent of age at culmination of mean annual increment (m. a. i.). It can be shown that, if delays in regeneration are included in rotation calculations, a 5-year regeneration delay defers culmination of c. a. i. by 5 years but of m. a. i. by nearly 10 years. Therefore, accurate measurement of c. a. i. in younger stands will suggest approximate rotation lengths. Projection of c. a. i. and m. a. i. curves will indicate yields for these rotations. Rotations with maximum production to top limits of 6 inches to 8 inches probably will be 10 to 20 years longer, depending partly on site quality and partly on thinning intensity.

Investigations of the effect of precommercial thinnings in Douglas-fir stands are underway (Williamson and Staebler 1965) and should soon indicate if such

stands will reach the production levels attained in foreign-managed plantations. Other checks on these levels can be made in stands 20 to 50 years old that were planted at wide spacings or received early thinnings. These can be measured to get early verification of the indications of foreign management tables.

If assumptions about equivalence of sites and height adjustments were changed, the indications of potential yield and culmination of yield for specified sites would be changed. However, it would require large changes in assumptions or adjustments to affect results drastically. Therefore, the average indications presented here are available as guides to potential yields under management practices equal in intensity to those applied in foreign plantations until experience with managed stands in the Pacific Northwest can improve them.

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APPENDIX I

Adjustments Made

To equate production classes in foreign tables with Northwest site indexes, several assumptions about height at 50 years were made. It was assumed that top height (height of the largest 100 trees per hectare or 40 per acre) in plantations corresponds to height of dominants in natural stands and can be adjusted by Staebler's (1948) equation to get equivalent height of dominants and codominants in natural stands. No difference in height was allowed for various methods used to estimate this top height or for using in its place height of largest 10 percent of stand. Two feet were added to height of largest 100 trees per acre to get top height. Six feet were added to mean height[4/] to get top height.[5/]

Uniform adjustments were made for all sites because of evidence presented by Pardé (1956), Warrack (1959), Decourt (1967), and W. Flöhr in Gohre (1958). Pardé (1956) found that dominant height was 3.6 feet greater than mean height. Warrack (1959) added 5 feet to mean height to get height of largest 100 trees per acre. Decourt (1967) added 9 to 11 feet to mean height to get top height. A table published by Göhre (1958) suggests adding 6.5 feet to mean height to estimate top height. Hummel and Christie (1953) added about 3.5 feet to Lorey's mean height to get height of largest 100 per acre. A graph published by Tveite (1967) suggests mean height averages about a foot taller than Lorey's height in plantations.

Outside-bark volumes were adjusted by deducting 13 percent for bark. Hummel et al. (1951) suggest 12.5 percent, Warrack (1959) used 14 percent, and Decourt (1967) 12.7 percent. Kanzow (1937) used 12 percent for his sites I and II and 13 percent for sites III and IV. Bernetti (1964) shows a range of 15.0 to 11.7 percent decreasing with size with most values near 12 percent. Johnson's (1966) equations suggest a deduction of between 14 and 15 percent, but his study included larger trees than others.

Five percent was added to volumes that excluded stump and tip to put all volumes on the same basis as Bulletin 201. It was estimated that total volume in tips would range from 1.3 to 2.7 percent of total volume at 50 years, depending on number of stems in thinnings and remaining stand. Low stumps were estimated to include 3 percent of total stem volume.

4/ Mean height in this paper is height of tree of mean basal area of entire stand.

5/ This equally well could have been 7 feet which would increase all indicated site indexes by 1.4 feet. One reviewer suggested an adjustment varying with site which would reduce indicated site 80 to 78, increase 140 to 142 and 170 to 174.

British yield tables were based on planting seedlings 2 to 4 years old, so 3 years were added to plantation age in their production tables to make tree growth comparable to other tables (except in appendix II). It was assumed that 2-year-old stock is planted in New Zealand.

APPENDIX II

DOUGLAS-FIR PLANTATION YIELDS WITH HIGH INTENSITY THINNINGS

Since many American forest managers are not accustomed to thinking in terms of cubic feet, one of the British yield tables (Bradley et al. 1966) was converted to American units including estimates of board-foot yields (table 3). This table should not be used without appropriate reductions from full acre yields previously discussed. It should also be noted that its board-foot estimates are based on short log scaling rules. Further, this table is for site 140. On site 110, annual production culminates 8 years later with 50 percent more trees in the stand averaging about 18 inches d.b.h.

All converting factors are listed below, with the exception of conversions from cubic feet (7-inch o.b. top) to board feet (6-inch i.b. top) Scribner formula rule for 16-foot logs. The latter conversions are included in the body of the yield table since they vary with average tree size. They were determined by use of taper tables for Douglas-fir on site III (unpublished report, Pacific Northwest Forest and Range Experiment Station files, November 15, 1945) and tree dimensions determined from listed top heights and mean diameters at various ages. The average trees were scaled in both cubic feet and board feet in logs 16.3 feet long measured to nearest 0.1-inch d.i.b., except for the top fractional log which was scaled to the length and diameter shown in the taper table.

An approximate conversion to long-log Scribner scaling was calculated by applying long-log rules to the entire stem to 6-, 7-, and 8-inch tops. (A stem 103 feet to a 6-inch top was scaled as one 6-inch 32-foot, one 13-inch 34-foot, and one 17-inch 34-foot log.) The individual tree conversion ratios were extremely erratic, ranging from nearly equal to Scribner formula conversion ratios to 70 percent of them. A deduction of 20 percent appears appropriate for this table as an average conversion from 16.3 feet formula Scribner to long-log Decimal C Scribner.

Converting factors:

Quarter girth (in.) x 1.273 = diameter (in.)
Basal area quarter girth (sq. ft.) x 1.273 = basal area (sq. ft.)
Hoppus feet x 1.273 = cubic feet
(Cubic feet o.b. to 3 inches o.b.) x 0.89 = (cubic feet total i.b.)
(Cubic feet o.b. to 7 inches o.b.) x 0.84 = (cubic feet i.b. to 7 inches o.b. above stump)
1.14 x (Scribner formula bd. ft.) = International 1/4 inch bd. ft.
0.80 x (Scribner formula bd. ft.) = long-log Scribner Decimal C bd. ft.

Table 3.-- *Douglas-fir yield class 240 Hoppus feet (3 inches o.b.) (equal to 272 cu. ft. total i.b.→site index 140 feet). Based on British Forest Management Tables 1966, converted to American units, full-acre yields*

Years after planting	Main crop--after thinning								Thinnings					
	Trees per acre	Top height (ft.)	Mean d.b.h. (in.)	Basal area per acre (sq. ft.)	Cubic-foot volume: Total	Cubic-foot volume: To 7-inch top, o.b.	Converting factor	Bd. ft., Scribner, to 6-inch top, i.b.	Trees per acre	Mean d.b.h. (in.)	Cubic-foot volume: Total	Cubic-foot volume: To 7-inch top, o.b.	Converting factor	Bd. ft., Scribner, to 6-inch top, i.b.
10	1,260	23.5	3.5	85	436	0	--	0	--	--	--	--	--	--
15	690	38.0	4.8	81	1,077	0	--	0	570	4.5	544	0	--	--
20	384	52.0	6.4	89	1,688	267	3.5	934	306	5.4	952	54	3.5	189
25	235	65.0	8.9	102	2,567	1,444	4.0	5,776	149	7.3	952	257	3.5	898
30	164	77.0	11.5	117	3,513	2,813	4.4	12,377	71	9.5	952	631	3.8	2,399
35	126	87.0	14.0	132	4,436	3,893	4.8	18,688	38	12.1	952	792	4.5	3,564
40	103	95.0	16.2	146	5,235	4,716	5.0	23,581	23	14.6	952	856	4.8	4,109
45	88	102.0	18.1	158	5,881	5,412	5.1	27,600	15	16.9	952	856	5.0	4,280
50	78	108.0	19.7	168	6,561	6,074	5.2	31,585	10	18.8	782	716	5.2	3,723
55	71	113.0	21.3	178	7,230	6,706	5.3	35,542	7	20.4	669	615	5.3	3,260
60	65	117.5	22.9	187	7,853	7,294	5.4	39,388	6	22.0	601	556	5.4	3,002
65	61	121.5	24.2	195	8,425	7,829	5.5	43,059	4	23.2	550	513	5.4	2,770
70	58	124.5	25.5	202	8,924	8,310	5.5	45,705	3	24.5	516	481	5.5	2,646
75	55	127.0	26.4	209	9,349	8,716	5.6	48,810	3	25.8	493	460	5.5	2,530
80	53	129.5	27.4	214	9,706	9,059	5.6	50,730	2	26.7	465	433	5.6	2,425

Years after planting	Total production				Mean annual production			Ratio: Main crop / Total production			Total production ratio: Cu. ft. 7-inch / Cu. ft. total
	Basal area per acre (sq. ft.)	Cubic-foot volume: Total	Cubic-foot volume: To 7-inch top, o.b.	Bd. ft., Scribner, to 6-inch top, i.b.	Cubic-foot volume: Total	Cubic-foot volume: To 7-inch top, o.b.	Bd. ft., Scribner, to 6-inch top, i.b.	Cubic-foot volume: Total	Cubic-foot volume: To 7-inch top, o.b.	Bd. ft., Scribner, to 6-inch top, i.b.	
10	85	436	0	0	44	0	0	1.00	--	--	0
15	143	1,621	0	0	108	0	0	.66	--	--	0
20	201	3,184	321	1,123	159	16	56	.53	0.83	0.83	0.10
25	257	5,015	1,755	6,863	201	70	275	.51	.82	.84	.35
30	309	6,913	3,755	15,863	230	125	529	.51	.75	.78	.54
35	355	8,788	5,627	25,738	251	161	735	.50	.69	.73	.64
40	395	10,539	7,306	34,740	263	183	868	.50	.65	.68	.70
45	429	12,137	8,858	43,039	270	197	956	.48	.61	.64	.73
50	460	13,599	10,236	51,020	272	205	1,020	.48	.59	.62	.75
55	486	14,935	11,483	57,964	272	209	1,054	.48	.58	.61	.77
60	510	16,159	12,627	64,812	269	210	1,080	.49	.58	.61	.78
65	531	17,281	13,675	71,253	266	210	1,096	.49	.57	.60	.79
70	549	18,295	14,637	76,545	261	209	1,094	.49	.57	.60	.80
75	565	19,213	15,503	82,180	256	207	1,096	.49	.56	.59	.81
80	579	20,035	16,279	86,525	250	203	1,082	.48	.56	.59	.81

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1969. Potential production in thinned Douglas-fir plantations. USDA Forest Serv. Res. Pap. PNW-87, 22 pp., illus. Pacific Northwest Forest & Range Experiment Station, Portland, Oregon.

Nine foreign production tables for Douglas-fir (thinning guides) were converted to American units of measure. They suggest that potential yields of thinned stands in the Pacific Northwest are higher than has been estimated on the basis of natural unthinned stands, and that culmination of merchantable mean annual production with heavy thinning may occur at 65 to 80 years.

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Headquarters for the PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION is in Portland, Oregon. The Station's mission is to provide the scientific knowledge, technology, and alternatives for management, use, and protection of forest, range, and related environments for present and future generations. The area of research encompasses Alaska, Washington, and Oregon, with some projects including California, Hawaii, the Western States, or the Nation. Project headquarters are at:

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